Effective elimination of contaminants after oral care in elderly institutionalized individuals

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A B S T R A C T

After mechanical cleaning in oral care, eliminating residual oral contaminants has an important role in preventing their aspiration, especially in individuals with weak airway protection. We examined the effectiveness of wiping the oral cavity after oral care on eliminating contaminants in 31 patients who were hospitalized in our neurology inpatient unit. The amount of bacteria on the tongue, palate, and buccal vestibule was counted before and just after oral care, after eliminating contaminants either by rinsing with water and suction or by wiping with mouth wipes, and 1 h after oral care. Oral bacteria amounts were decreased significantly by both elimination procedures after oral care. These findings suggest that wiping with mouth wipes is as effective as mouth rinsing to decrease bacteria following oral care. With a lower risk of contaminant aspiration, wiping may be a suitable alternative to rinsing, especially in dysphagic individuals.

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Bacterial colonization of the oral cavity is considered to be the reservoir for respiratory pathogens. Bacterial dental plaque is a dynamic environment composed of extracellular matrix and oral bacteria, wherein certain bacteria initiate biofilm formation on the tooth surface. In the early stages of colonization, colonizers include many species of oral streptococci and other natural microbiota, which are not known as respiratory pathogens. In contrast, later colonizers, such as Fusobacterium nucleatum, Tannerella forsythia, Treponema denticola, and P. gingivalis, are more pathogenic. These earlier and later colonizers exhibit interspecies adhesive interactions to enhance biofilm formation.

Enzymes and immunoglobulins in the saliva control the colonization of microorganisms in the oral cavity and protect against biofilm build-up on the tooth surface. However, in frail institutionalized elderly patients, poor oral hygiene from diminished physical function, xerostomia derived from medication, systemic diseases, oral breathing, and other factors provide favorable conditions for the formation of dental plaque biofilm. Such patients often unconsciously aspirate saliva. If they have poor oral hygiene, micro-aspiration of pathogenic aerodigestive secretions from the oral cavity may lead to aspiration pneumonia. Teramoto et al reported that the incidence of aspiration pneumonia was high in hospitalized patients in the forms of health care-acquired pneumonia (HCAP) and hospital-acquired pneumonia (HAP).

Several studies have reported that oral care to improve oral hygiene reduces the risk of HAP, including ventilator-associated pneumonia, and HCAP. Although oral care is now recommended to prevent respiratory complications, it is sometimes difficult for caregivers, who have expressed a desire for effective oral care standards. In order to standardize the oral care procedure, protocols of mechanical dental plaque removal with an electric or hand toothbrush, along with the use of sponge swabs, a tongue scraper, and/or chemical decontamination with chlorhexidine, have
been broadly established.\textsuperscript{10,11,13} Standardized protocols that unify such procedures are expected to maintain universal oral health standards.\textsuperscript{13}

Previous studies on oral care protocols have typically focused on cleaning and less on the elimination of contaminants after cleaning.\textsuperscript{10,11} An amount of displaced contaminants remain in oral cavity saliva after the mechanical removal of dental plaque and food debris. If not properly removed, these contaminants flow into the pharynx and may eventually be aspirated into the lower airway in individuals with weak airway protection. To eliminate contaminants after oral care, swishing/rinsing and spitting is normally performed if the patient is able to gargle. Rinsing and suction can also be used for patients who are not fully conscious or who are totally dependent on assistance.\textsuperscript{5} In such cases, however, rinse water can easily reach the pharynx due to its rheological properties, thus increasing the risk of aspiration.

In a preliminary study of healthy subjects, we earlier examined the effect of wiping the oral cavity on eliminating contaminants after oral care as compared with rinsing.\textsuperscript{14} We demonstrated that wiping with mouth wipes decreased the amount of oral bacteria on soft tissue surfaces in the oral cavity more effectively than with water rinsing. Wiping can avoid the risk of rinse water aspiration, and was considered to be an alternative procedure for contaminant elimination after oral care. The present study therefore aimed to evaluate wiping as a method of eliminating contaminants after oral care in a cohort of elderly institutionalized individuals.

**Methods**

**Subjects and materials**

We conducted a prospective cross-over trial in the neurology unit of our hospital from June 2013 to November 2013. The sample size was calculated based on our previous study with healthy individuals for a two-tailed significance level, a type I error of 0.05, and a type II error of 0.10 (power = 0.90).\textsuperscript{14} Patients who were not able to properly brush their teeth by themselves were recruited. Patients were excluded if they were edentulous, of unstable general physical condition, or had a bleeding tendency. This study’s protocol was approved by the Institutional Review Board of Fujita Health University (Approval ID: 13–094).

A total of 37 patients were approached for this study, and all agreed to participate. Before commencement, informed consent was obtained from each participant or the caregiver if the subject could not adequately communicate (Glasgow Coma Scale grades below 4-4-6). Six patients dropped out before or during the study since five refused to continue and one died due to recurrent cerebral infarction. Overall, 31 individuals (17 men, 14 women; mean age: 69.9 ± 15.1 years) participated in this study. Physical function was assessed using the Barthel Index (BI, adapted from Granger et al)\textsuperscript{15} by neurology unit nurses. The BI is a scale that measures ten basic aspects of activity related to self-care and mobility. A normal BI score is 100, with lower values indicating a need for assistance in activities of daily living. Comorbidities, medications, and diet status were also evaluated. The number of teeth and denture use were assessed by hospital dentists. The cohort’s characteristics are shown in Table 1.

**Procedures**

Neurology unit nurses performed oral care after breakfast on patients who were fed orally or after 7 am on patients who were not. Participants who could somewhat brush their teeth were instructed to abstain from brushing during the study period. Subjects were also instructed not to consume any food or drink during the period of oral bacteria measurement until the final assessment 1 h after oral care.

The oral care protocol was developed with a nurse certified in dysphagia, neurology unit nursing staff, a dentist, and a dental hygienist. Oral moisturizing gel (Oral plus moisturizing gel for oral care, Wakodo Co Ltd., Tokyo, Japan) was first applied to the soft surfaces of the oral cavity to soften any dried or hard secretions. The moisturizing gel contained hyaluronic acid and trehalose and had a high water content (75% or more) to prevent transpiration and moisten the inside of the mouth. Afterward, the teeth were brushed without a dentifrice with a hand toothbrush and interdental brush if necessary. The toothbrush was dipped into one of two cups of tap water before brushing, and was occasionally rinsed first in one cup, and then the other, when needed. The tongue was cleaned with a tongue scraper by scraping from the back to the front of the tongue surface 10 times. The palate and the other soft tissues were mechanically cleaned with a sponge swab. After oral care, residual contaminants in the oral cavity were eliminated using one of the two procedures described below. Finally, a measured amount of moisturizing gel was applied to the soft tissues of the oral cavity.

Two procedures for eliminating contaminants were adopted after mechanical cleaning of the teeth, tongue, and gums: (1) Rinse; the mouth was rinsed with 30 mL tap water from an irrigating syringe and suctioned with an oral suction handle. (2) Wipe; the entire mouth, including the teeth, gums, tongue, and palate, was wiped with an oral care mouth wipe (Oral Plus, Wakodo Co Ltd., Tokyo, Japan). The mouth wipe had a texture similar to that of a baby wipe and was designed to clean the soft tissues of the mouth. The sheet was composed mainly of cellulose fibers, with a small amount of plastic fibers to bind them. It contained hyaluronic acid and trehalose for moisturization, but no alcohol or antimicrobial compounds. Both procedures were conducted on each subject on different days that were at least 24 h apart.

The amount of bacteria on the following places in the oral cavity was measured by a bacteria detection apparatus (Panasonic healthcare, Tokyo, Japan) before oral care, just after oral care, after eliminating contaminants, and 1 h after oral care (Fig. 1): (1) the dorsal surface of the tongue (tongue); (2) the palatal area between the hard and soft palates (palate); and (3) the buccal vestibule area of the lower right molars (buccal vestibule).

<table>
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<th>Table 1 Characteristics of the study population.</th>
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<tr>
<td>Age (yrs)</td>
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<tr>
<td>Barthel index</td>
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<td>No. of teeth</td>
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<td>Gender</td>
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<td>Male</td>
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<td>Female</td>
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<td>Disease</td>
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<td>Cerebral infarction</td>
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<td>Parkinson’s disease</td>
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<td>Spinocerebellar degeneration</td>
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<td>Multiple sclerosis</td>
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<tr>
<td>Others</td>
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<tr>
<td>Diet status</td>
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<tr>
<td>Peripheral parenteral nutrition</td>
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<tr>
<td>Enteral nutrition</td>
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<td>Enteral nutrition with small amount of oral diet</td>
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<tr>
<td>Oral diet with some modifications</td>
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<td>Oral diet with no restrictions</td>
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Bacteria in the oral cavity were measured in a standardized way based on a previous study. Briefly, a sterilized swab was pressed on the sampling area with a constant force of 20 g using a device on the bacteria detection apparatus. The swab was wiped on the applicable areas three times in a 10 mm swath. The swab was then placed in distilled water in the bacteria detection apparatus for counting. Bacteria quantification utilized the dielectrophoretic impedance measurement (DEPIM) technique. The calculated numbers of bacteria [cfu/mL] were stored in the apparatus until computer analysis.

Data analysis

We tested differences in the number of bacteria at each location and at each time point from before oral care to 1 h after oral care using Friedman's rank test. The Wilcoxon test with Bonferroni correction was adopted for multiple comparisons. The critical value for rejecting the null hypothesis was p < 0.05. Statistical analyses were performed using SPSS 20.0 software (SPSS Inc., Chicago, IL).

Results

Mean BI (mean ± SD) score of participants was 28.7 ± 28.6. Only seven patients had a score of over 60, indicating an assisted independence level, while 22 patients scored below 40 and required substantial assistance in activities of daily living. In the protocol of this study, all oral care was performed by nurses even if the participants could somewhat brush their teeth.

There were no statistical differences in the amount of oral bacteria between the rinse and wipe groups at any of the three locations before oral care (p = 0.78 for the tongue, p = 0.71 for the palate, and p = 0.89 for the buccal vestibule). Overall, the amount of bacteria decreased significantly with rinsing or wiping after oral care at all locations for both groups (Fig. 2). However, there were no significant differences in the amount of oral bacteria between the time points of before oral care and 1 h after oral care.

Tongue

In the rinse group, the amount of oral bacteria on the dorsal tongue surface was not significantly different after the oral care procedure, but this decreased significantly after rinsing from 1.38 × 10^7 (median [interquartile range]: 6.50 × 10^6–3.70 × 10^7) cfu/mL to 9.17 × 10^6 (2.98 × 10^6–2.32 × 10^7) cfu/mL (p = 0.035).

In the wipe group, the amount of bacteria on the tongue surface was also not significantly changed after oral care, but it decreased significantly after wiping from 1.38 × 10^7 (5.67 × 10^6–3.24 × 10^7) cfu/mL to 6.44 × 10^6 (9.09 × 10^5–1.43 × 10^7) cfu/mL (p = 0.035).

Palate

In the rinse group, the amount of bacteria on the surface of the palate increased significantly from 3.45 × 10^6 (1.39 × 10^6–2.11 × 10^6) cfu/mL before oral care to 1.30 × 10^7 (4.76 × 10^6–5.90 × 10^7) cfu/mL afterward (p = 0.035), but this decreased significantly after rinsing to 2.76 × 10^6 (1.19 × 10^6–6.96 × 10^6) cfu/mL (p = 0.001).

In the wipe group, the amount of bacteria on the palate did not markedly rise after oral care, but it significantly decreased from 5.11 × 10^7 (1.49 × 10^7–1.83 × 10^8) cfu/mL after oral care to 1.74 × 10^6 (1.00 × 10^6–6.10 × 10^5) cfu/mL after wiping (p = 0.002). The amount of bacteria increased 1 h after oral care compared with that just afterward (4.22 × 10^5 [1.96 × 10^5–1.12 × 10^6] cfu/mL) (p = 0.047).

Buccal vestibule

In the rinse group, the amount of bacteria on the buccal vestibule area increased from 1.29 × 10^6 (5.20 × 10^5–6.43 × 10^6) cfu/mL before oral care to 5.65 × 10^6 (1.26 × 10^6–9.87 × 10^5) cfu/mL afterward, which approached statistical significance (p = 0.084). This decreased significantly after rinsing to 6.78 × 10^5 (1.75 × 10^5–1.35 × 10^6) cfu/mL (p < 0.001).

In the wipe group, the amount of bacteria on the buccal vestibule increased significantly from 1.52 × 10^6 (4.06 × 10^5–5.08 × 10^6) cfu/mL before oral care to 2.44 × 10^6 (1.11 × 10^6–6.88 × 10^5) cfu/mL afterward (p = 0.035). It decreased significantly after wiping to 3.75 × 10^5 (1.00 × 10^5–6.10 × 10^5) cfu/mL (p < 0.001), and this reduction persisted to 1 h after oral care (p = 0.006).

Discussion

The oral health condition of frail institutionalized elderly patients is easily deteriorated by systemic diseases, diminished physical function, and xerostomia, thus providing favorable conditions for dental plaque biofilm formation. If the biofilm is not properly eliminated by mechanical cleaning in the early stages of colonization, pathogenic bacteria may subsequently proliferate in later colonization. Moreover, several studies have reported that oral care intervention reduces the incidence of HAP or HCAP, indicating that it has an essential role in preventing aspiration pneumonia.

After the mechanical removal of dental plaque with oral care, some displaced microorganisms remain in the saliva and may become subject to micro-aspiration in patients with dysphagia. Thus, an established procedure for eliminating removed dental plaque biofilm and food debris in secretions after cleaning may be as important as mechanical removal itself to avoid unnecessary aspiration of biofilm substances. If patients cannot gargle by themselves due to low consciousness or total dependence, the removed dental plaque biofilm present in secretions is usually rinsed and suctioned. However, rinse water can easily reach the pharynx due to its rheological properties in such patients, which increases the risk of aspiration. In the present study, we examined the effectiveness of mouth wiping, a procedure that precludes the chance of additional rinse water aspiration, on eliminating contaminants after oral care as an alternative procedure to rinsing the mouth.

In earlier oral care protocols for critically ill and/or intubated patients, rinsing with water and suction was frequently used after...
mechanical cleaning of the oral cavity. Suction following rinsing was important because if absent, contaminated secretions would pass into the pharynx and lower airway in patients with a weak airway protective mechanism. The present study demonstrated that wiping the mouth with mouth wipes significantly decreased the amount of oral bacteria to an extent comparable to rinsing at all three sampling locations. For patients with weak airway protection, rinsing with a water syringe may increase the risk of aspirating the rinse water. Wiping can significantly mitigate this chance since it requires no additional fluid. Meanwhile, simple swishing with tap water and spitting is recommended for removing contaminants in conscious patients who can keep water in the oral cavity when rinsing.

The median number of oral bacteria tended to be higher after oral care than that beforehand, although the difference was only significant on the palate in the rinse group and on the buccal

Fig. 2. Changes in the amount of oral bacteria on three soft tissue locations at four time points from before oral care to 1 h after oral care. Rinse: rinsing with tap water and suction with an oral suction tip. Wipe: wiping with mouth wipes for oral care. At all locations, the amount of oral bacteria decreased significantly after elimination of contaminants for both rinsing and wiping. *p < 0.05; **p < 0.01.
vestibule in the wipe group. Increased bacteria at these locations were reduced by rinsing or wiping, which emphasized the importance of eliminating contaminants after oral care. However, there were no significant differences in the amount of bacteria before and 1 h after oral care. This suggests that oral bacteria returns to a baseline level as early as 1 h after cleaning. The surfaces of soft oral tissues and the teeth enable microbial colonization in both dentulous and edentulous individuals. While earlier colonizers are mostly commensal bacteria and are fairly harmless, later colonizers tend to contain more respiratory pathogens. Disrupting dental plaque in its early stages may prevent later colonizers from adhering to the tooth surface, resulting in a reduced risk of respiratory complications. Daily oral care by a health care provider is therefore critical to prevent increases of these microorganisms.

The median number of oral bacteria was approximately 10^7 cfu/ml on the tongue surface, but only 10^5 to 10^6 cfu/mL on the palate or buccal vestibule. Sachdeo et al investigated the microbiota on soft oral tissue surfaces in edentulous subjects wearing complete dentures and found that bacterial counts were highest on the dorsal surface of the tongue and lower on the labial vestibules and palate. They also reported that the microbial species present in the saliva and on the dorsal tongue surface were in the same cluster. Our results are consistent with this study and suggest that cleaning the tongue surface is essential in an oral care protocol. We employed a tongue scraper for tongue cleaning in our cohort. The number of bacteria did not change with mechanical cleaning only, but decreased significantly after rinsing or wiping the tongue surface. Thus, eliminating microorganisms on the tongue surface by scraping may be important for effective oral care.

All of the patients enrolled in this study were taking multiple medications and had various comorbidities. We did not assess dryness of the mouth in our cohort, but we suspect that most subjects had some degree of xerostomia derived from polypharmacy or comorbidities. Oral conditions may also have differed among subjects and affected oral care and elimination results. However, by comparing the two elimination methods after oral care within the same subjects, we presumed that comorbidities and medications had a minor influence on our findings.

The present study only demonstrates the short-term effect of wiping with mouth wipes on the reduction of oral bacteria. Further studies are needed to examine the long-term effect of wiping as an elimination procedure of oral contaminants for reducing the risk of aspiration pneumonia.

Conclusion

We examined the effectiveness of wiping the mouth with mouth wipes as a means to reduce oral bacteria after oral care. We witnessed that the amount of bacteria decreased significantly with wiping to a degree comparable to rinsing with water and suction. Our findings suggest that wiping with mouth wipes may be an alternative procedure to eliminate contaminants after oral care that prevents the unnecessary risk of aspiration and possible pneumonia in institutionalized dependent patients.

Acknowledgments

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